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ABSTRACT

This document is an instructional module package prepared in objective form for use by an instructor familiar with chlorine, the reasons for chlorination and safe operation and maintenance of gas chlorine, dry calcium hypochlorite and liquid sodium hypochlorite chlorination systems for water supply and wastewater treatment facilities. Included are objectives, instructor guides, student handouts and transparency masters. The module considers purposes of chlorination, properties of chlorine, methods of chlorination, safety, maintenance of chlorination units and interpretation of test results. (Author/RH)

CHLORINATION

Training Module 2.300.2.77

Prepared for the

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by

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September, 1977

The mention of trade names, or use of manufacturers technical bulletins, diagrams depicting specific equipment, or the commercial product in this module is for illustration purposes, and does not constitute endorsement or recommendation for use by Kirkwood Community College nor by the Iowa Department of Environmental Quality.

Module No:	Module Title: Chlorination
	Submodule Title:
Approx. Time: 15 hours	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. Define the purpose of chlorination in water and wastewater.
2. Define the methods of chlorination and the reaction in water and wastewater.

Instructional Aids:

Handouts
Overheads
Optional: Movies
Field trip

Instructional Approach:

Lecture
Discussion
Optional: Movies
Field trip

References:

1. Operation of Wastewater Treatment Plants, Sacramento
2. Wastewater Engineering, Metcalf and Eddy
3. Basic Gas Chlorination Workshop
4. Disinfection - ASCE - APHA
5. Water Chlorination Principles and Practices, AWWA
6. Chlorination of Wastewater MOP #4 WPCF

Class Assignments:

Participate in discussion
Read Handouts
Prepare handout

Module No:	Topic: Instructors Guide
Instructor Notes:	Instructor Outline:

1. Movies that may be used are at the discretion of the instructor. It will be up to the instructor to find pertinent films as the sources are many
2. Field trips are recommended to point out the many methods of chlorine application.
3. Do not use dry chlorine demonstration in an unapproved container as heat generated is high. N.B.: Demonstrate only in properly ventilated room !!!
4. Handout list indicates the number of handouts in package.
5. Most of the handouts may also be used as overheads.
6. Where discussion test interpretation, this unit section should be preceded with tests used in the plant. This will make this section easier to explain.

LIST OF HANDOUTS

1. Purpose Definitions
2. PPG Properties
3. Halogen Family
4. Forms of Chlorine
5. First Aid
6. Chlorination Points
7. Free Available Chlorine
8. Gas Chlorine
9. Calcium Hypochlorite
10. Sodium Hypochlorite
11. Pressure System
12. Vacuum Application
13. Vacuum System
14. Connection to Tank
15. Chlorine Safety

Module No:	Module Title: Chlorination
	Submodule Title: Introduction
Approx. Time: 45 minutes	Topic: Purpose/Definitions

Objectives:

Upon completion of this module the participant will be able to:

1. Identify the purpose of chlorination
2. Define:
   a. Free available chlorine
   b. Chlorine residual

Instructional Aids:

Handout 1

Instructional Approach:

Lecture
Discussion

References:

1. WPCF MOP #4 Chlorination in Wastewater
2. AWWA M 20 Water Chlorination Principles and Practices

Class Assignments:

Participate in discussion
Fill out handout

Module No:	Topic: Chlorination

Instructor Notes:	Instructor Outline:

I. Purpose

To reduce pathogenic bacteria preventing spread of water borne disease. Do not confuse with the sterilization of water. This is the total reduction of pathogens--to sterilize is not practical and is too costly.

Caution: Chlorine is a non-selective agent and could kill off organisms that are beneficial to the process.

II. Definitions

1. Chlorine demand
2. Chlorine residual
3. Free available chlorine

1. Demand - the difference between the amount of chlorine added and the amount of chlorine remaining in a solution at the end of a specific period of contact.
2. Residual - the amount of chlorine available as a dissolved gas, acid, or ion that will combine with any organic compound.
3. Amount of chlorine available in a liquid that is not combined with any organic compound.

III. History

1774, Paris, France, Eau de Javelle (Scheele)

1785, Berthollet - used this in the textile mills Potash solution and chlorine makes Eau de Javelle

Handout 1

CHLORINATION

Purpose:

Definitions:

Chlorine Demand

Chlorine Residual

Free Available Chlorine

Module No:	Module Title: Chlorination
	Submodule Title: Background Information
Approx. Time: 2 hours	Topic: Properties

Objectives:

Upon completion of this module the participant will be able to:

1. List properties of chlorine.

Instructional Aids:

Handouts 2 & 3

Instructional Approach:

Lecture
Discussion

References:

1. PPG Industries
2. Disinfection, ASCE, APHA

Class Assignments:

Participate in discussion

Module No:	Topic:
Instructor Notes:	Instructor Outline:
Handout (PPG) 2 Handout 8 (Read from overhead)	IV. Background Information Read from handout (Properties) VI. Cl_2 Family Member Halogen family

CHLORINE

As one of the largest merchant producers of chlorine in North America, the Chemical Division of PPG Industries is a dependable supplier producing and shipping from a grid of five strategically located plants.

PPG has accumulated more than 35 years of chlorine production and handling experience. During this time PPG has shipped more than 12 million tons of chlorine.

PPG personnel are highly experienced in handling and shipping chlorine, and the Chemical Division's technical service engineers can provide expert technical assistance to chlorine users. Technical service is backed up by research and analytical laboratories and industry oriented laboratories serving industries such as pulp and paper, textiles and chlorinated solvent uses.

To aid users in training plant personnel, PPG has produced a 30-minute color film, "Safe Handling of Chlorine," and has published a pocket size guide on the same subject, as well as an 84-page, hard cover manual on "Chlorine".

Uses

Chlorine serves as a reactive intermediate to make a host of organic and inorganic chemicals. The chemical industry consumes nearly three quarters of the total U. S. chlorine production.

Organic chemicals account for nearly two thirds of this total. These include solvents, insecticides, refrigerants, propellants, lubricant additives, and monomers for making plastics such as polyvinylchloride.

Pulp and paper bleaching is the second largest use of chlorine. It is also used for bleaching textiles.

Inorganic chemical uses include many of the chlorides needed for metallurgical processing.

Water and waste treatment--Chlorine is the major chemical used for the sanitation of water.

Properties

Chemical Name: Chlorine

Chemical Formula: Cl_2

Molecular Weight: 70.914

Description: Liquid chlorine is mobile and has a clear, amber color. The gas is greenish yellow and has a characteristic penetrating, irritating odor.

Specific Gravity of Dry Gas at 0° C. (32° F) and 1 atm pressure (air = 1)	2.482
Specific Gravity of Liquid 0° C/4° C (32°/39° F.)	1.468
Boiling Point	-34.06° C. (-29.31° F.)
Heat of Vaporization at the boiling point	
Btu/lb	123.7
cal/g	68.8
Specific Heat of Gas	
At constant pressure, C_p at 15° C. cal/(g) (° C)	0.115
At 59° F., Btu/(lb) (° F.)	0.115

At constant volume, C_v	
At 15° C. cal/(g) (° C.)	0.0849
At 59° F, Btu/(lb) (° F.)	0.0849
Specific Heat Ratio, C_p/C_v	1,355
Specific Heat of Liquid	
At 0 to 24° C, cal/(g) (° C.)	0.226
At 32 to 75° F. Btu/(lb) (° F.)	0.226
Liquid Gas Volume Relationship	
At 0° C (32° F) and 1 atm pressure	1 volume liquid chlorine = 456.8 volumes chlorine-gas
	1 pound liquid chlorine = 4.98 ft^3 of chlorine gas
Volume Temperature Relationship	The volume of liquid chlorine increases rapidly as its temperature increases

Solubility: Chlorine gas has only limited solubility in water--up to 1%. Solubility increases with an increase in alkalinity.

Reactivity: Because it is highly reactive, chlorine is never found free in nature. Its most common compound is sodium chloride, from which PPG manufactures chlorine by electrolysis. Chlorine reacts with most of the elements and many organic and inorganic compounds usually with the evolution of heat. Unless controlled, these reactions may have violent results.

Government Specifications

PPG chlorine meets the chemical and physical requirements of Federal Specification BB-C-120, that: "Chlorine shall be 99.5% pure by volume as obtained from vaporized liquid chlorine."

Toxicity

Chlorine gas is primarily a respiratory irritant. Concentrations above three to five parts per million in air have a readily detectable odor. In concentrations above 15 ppm it irritates the mucous membranes, the respiratory system and the skin. Concentrations between 40 and 60 ppm are dangerous in 30 to 60 minutes. Exposure to air containing 1,000 ppm is fatal in a very short time.

Concentrations in work areas should not exceed one ppm as a time weighted average atmospheric concentration for an eight hour day to avoid adverse inhalation effects on workmen. This is its threshhold limit value (TLV).

Liquid chlorine may cause skin and eye burns upon contact. When exposed to standard atmospheric temperature and pressure, liquid chlorine vaporizes to chlorine gas.

More information appears in Chemical Safety Data Sheet, SD-80 on "Chlorine" published by the Manufacturing Chemists Association, 1825 Connecticut Avenue, N. W., Washington, D. C. 20009.

Handling and Storage

Since chlorine gas is about 2½ times as heavy as air, it settles toward the ground and collects in low spots. This property is important to persons planning the location and ventilation of storage areas.

Dry chlorine containing less than 150 ppm moisture, as manufactured by PPG Industries, does not corrode common metals appreciably at temperatures below 110° C. (230° F.) However, chlorine reacts with moisture to form hydrochloric and hypochlorous acids, which are highly corrosive. This property is responsible for the following precautions:

1. Make sure that piping is dry before admitting chlorine.
2. Use only dry (-40° dew point minimum) oil-free air or nitrogen for purging, testing for leaks or padding tank cars.
3. Never use water to detect or absorb leaking gas, and never put a leaking container into water.

Fire and explosion hazards: Chlorine liquid and gas by themselves are non-flammable and nonexplosive. However, chlorine can support the combustion of certain substances. For example, carbon steel ignites at 251° C. (483° F.) in the presence of chlorine gas, and finely divided metal ignites even more readily.

Many organic chemicals react readily with chlorine--some with explosive violence.

Information: PPG has published an 84-page manual, "Chlorine", which describes in detail its properties, as well as handling and storage. PPG also distributes a pocket-size guide for operating personnel on the "Safe Handling of Chlorine."

In Case of Emergency

In case of an emergency with a leaking chlorine container, telephone the nearest PPG Chemicals plant. Plants can be reached by phone at any time, day or night. We have trained men equipped with emergency equipment for

handling such conditions.

PPG Plant Emergency Telephone Numbers

Barberton, Ohio

216-753-4561

Corpus Christi, Texas

512-883-4301

Lake Charles, Louisiana

318-882-1200

Natrium, West Virginia

304-455-2200

In Canada; Beauharnois, Quebec

Standard Chemical Limited

514-429-4641

Packaging and Shipping

PPG ships liquid chlorine in tank cars, barges, ton containers and tank truck.

Tank Car

Most chlorine shipments are made in single-unit tank cars with capacities of 16, 30, 55, 85 and 90 tons. Shipping points are Barberton, Ohio; Corpus Christi, Texas; Lake Charles, Louisiana; Natrium, West Virginia; and in Canada, Standard Chemical Limited, Beauharnois, Quebec.

Barge

PPG pioneered barge shipment of chlorine and currently has barges

of 600, 900, and 1100 tons capacity. Shipping points are Lake Charles, Louisiana, and Natrium, West Virginia.

Ton Tanks

Ton containers are filled with 2000 pounds of liquid chlorine and have a tare weight of approximately 1550 pounds. They are shipped in multiple-unit tank cars commonly called "cradle cars", which have spaces for 15 containe Less than carload quantities are shipped in trucks, which can carry from eight to ten containers. Shipping points are Barberton, Ohio; Corpus Christi, Texas; and Lake Charles, Louisiana.

Truck

In some cases, users prefer to receive chlorine shipments in specially designed, single-tank trucks, which have a nominal capacity of 17 tons.

Technical Assistance

The technical service staff of PPG Industries Chemical Division is also available in case of emergency as well as routinely for consulting on handling, storage and use.

HALOGEN Family (VII)

FLOURINE (F)

CHIORINE (Cl)

BROMINE (Br)

IODINE (I)

ASTATINE (A+)

Module No:	Module Title: Chlorination
	Submodule Title: Forms of Chlorine
Approx. Time: ½ hour	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. List the forms of chlorine and the percent of chlorine available.

Instructional Aids:

Handout 4

Instructional Approach:

Lecture
Discussion

References:

1. Suppliers Material

Class Assignments:

Participate in discussion
Prepare handout

Module No:	Topic: Forms of Chlorine

Instructor Notes:	Instructor Outline:

III. Forms of Cl_2

1. Gas 99.5% pure Cl_2
2. Liquid Sodium Hypochlorite (bleach) 5% - 70%

   Brand names

   HTH - Powder
   Perchloron - Powder
   Sanuril - Tablets

Handout 4

FORMS OF CHLORINE.

% Available

Gas

Liquid

Dry

Module No:	Module Title: Chlorine
	Submodule Title: First Aid
Approx. Time: ½ hour	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. List the steps for first aid treatment.

Instructional Aids:

Handout 5

Instructional Approach:

Lecture
Discussion

References:

1. Chlorination of Wastewater MOP #4.
2. Operation of Wastewater Treatment Plants, Sacramento

Class Assignments:

Participate in discussion
Prepare handout

Module No:	Topic: First Aid
Instructor Notes:	Instructor Outline:

IX. First Aid

1. Get outside
2. Keep victim warm (70^{0} F.)
3. Call a doctor
4. Remove victims wet clothes
   N.B. Cl_2 burns in solution
5. If not breathing use respirator
6. Reduce or stop coughing if possible
7. Do not administer drugs or liquids

Handout 5

CHLORINATION

1.

2.

3.

4.

5.

6.

7.

Module No:	Module Title: Chlorination
	Submodule Title: Application Points
Approx. Time: 2 hours	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. Identify points of application of chlorine.
2. Reasons for chlorine application.

Instructional Aids:

Handout 6

Instructional Approach:

Lecture
Discussion

References:

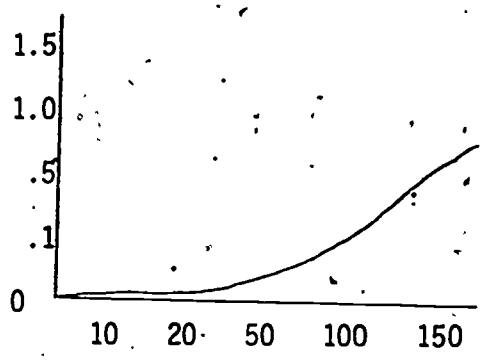
1. Chlorination of Wastewater MOP #4 WPCF
2. Water Chlorination Principles and Practices - AWWA

Class Assignments:

Prepare handout
Participate in discussion

Module No:	Topic: Chlorination
Instructor Notes:	Instructor Outline:

X. Chlorine Reactions in Water



Breakpoint Cl_2 - same as free available residual; ammonia in the wastewater helps in producing free available residual chlorine and increases the kill ratio. However, this is not practical in wastewater due to high costs to overcome ammonia. Practical in water treatment.

XI. Application Points

Outside plant for:

1. Odor control in sewers and manholes
2. Slime and algal growth
3. H_2S oxidation

Where:

1. Forced mains
2. Pump suction wells
3. Wet wells
4. Sewer mains
5. Manholes

Dosage:

4 - 6 mg/l or without residual

Handout 6

CHLORINE APPLICATION POINTS

Outside Plants:

1.

2.

3.

Where:

1.

2.

3.

4.

5.

Common Dosage:

Module No:	Topic: Chlorination
Instructor Notes:	Instructor Outline:

Corrosion Control

$H_2S + O_2 \longrightarrow H_2SO_4$ (simplify)

Acid eats pipe

Concrete pipe reaction creates calcium sulfate $CaSO_4$

Forced Mains - water mains, all drinking water distribution systems will be chlorinated after a pipe break or repair and in a new system.

A. Method

a. Apply chlorine to one end of the main to be sterilized while bleeding at the other end.

b. Measure application with bleed off carefully.

c. Allow solution to stand for a given period.

d. Bleed of solution or discharge into system.

Example:

Drop dilution method

Material Needed:

1 pt. distilled water

1 ml eyedropper w/ability to drip 20 drops per 1 ml.

Residual chlorine compared with 15 ml. vial and .5 ml dropper

Procedure

a. Collect small sample

b. Add .5 ml orthotolidine to one vial and fill to 15 ml. mark.

Module No:	Topic: Chlorination
Instructor Notes:	Instructor Outline:

c. Fill other vial with distilled water to 15 ml. mark.

d. Add 1 drop of water to be tested to the vial containing orthotolidine mix and repeat until a color develops.

e. Measure the color on the comparator.

f. Record total drops of sample added to the solution.

Computation of Residual

a. Divide 15 ml. of sample vial by the total ml. used of sample (.05 ml per drop) = dilution factor.

b. Multiply residual reading shown on comparator by the dilution factor = residual.

Module No:	Module Title: Chlorination
	Submodule Title: Reaction of Chlorine in Waters
Approx. Time: 2 hours	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. Identify the reaction of chlorine forms in water.

Instructional Aids:

Handouts 7, 8, 9, & 10

Instructional Approach:

Lecture
Discussion

References:

1. AWWA Water Chlorination Principles and Practices, AWWA
2. WPCF MOP #4 Chlorination of Wastewater
3. Operation of Wastewater Treatment Plants, Sacramento

Class Assignments:

Participate in class discussion.

Module No:	Topic:

Instructor Notes:	Instructor Outline:

Handout 7

XII. Reaction of Cl_2

1. Water

Theoretical

pH	% HOCl	% OCl
4	100.0	0.0
5	99.7	0.3
6	96.8	3.2
7	75.2	24.8
8	23.3	76.7
9	2.9	97.1
10	0.3	99.7
11	0.03	99.47

Handout 8

Free available chlorine

$HOCl + OCl^-$

A. Reduction of bacteria is due to the creation of:

a. Acidic condition
b. Attacking on enzymes
c. Creation of spores to portect bacteria from harmful attack

Still a mystery. All are theories

2. Wastewater

Data similar to water with the addition of the solids, organic, inorganic matter and ammonia.

Handout 9

3. Chlorine Compounds

A. Calcium Hypochlorite - reaction w/water

$Ca(OCl)_2 \quad Ca^{2+} \; 2\,OCl^-$

Handout 10

B. Sodium Hypochlorite - reaction w/water

$NaOCl \quad Na^+OCl^-$

FREE AVAILABLE CHLORINE

HOCl

plus

OCl

$$Cl_2 + H_2O \rightleftharpoons$$

$$HOCl + H^+ + Cl^-$$

$$HOCl \rightleftharpoons H^+ + OCl^-$$

Calcium Hypochlorite

$$Ca(OCl)_2 \longrightarrow$$

$$Ca^{2+} + 2OCl^-$$

Handout 9

Sodium Hypochlorite

$NaOCl \rightarrow$

$Na^{+} + OCl^{-}$

Module No:	Module Title: Chlorination
	Submodule Title: Application of Methods
Approx. Time: 2 hours	Topic: Pressure/Vacuum

Objectives:

Upon completion of this module the participant will be able to:

1. Identify parts of pressure systems and the operation of system.

Instructional Aids:

Handout 11, 12, 13, & 14

Instructional Approach:

Lecture
Discussion

References:

1. Operation of Wastewater Treatment Plants, Sacramento
2. Equipment Manufacturers Guide

Class Assignments:

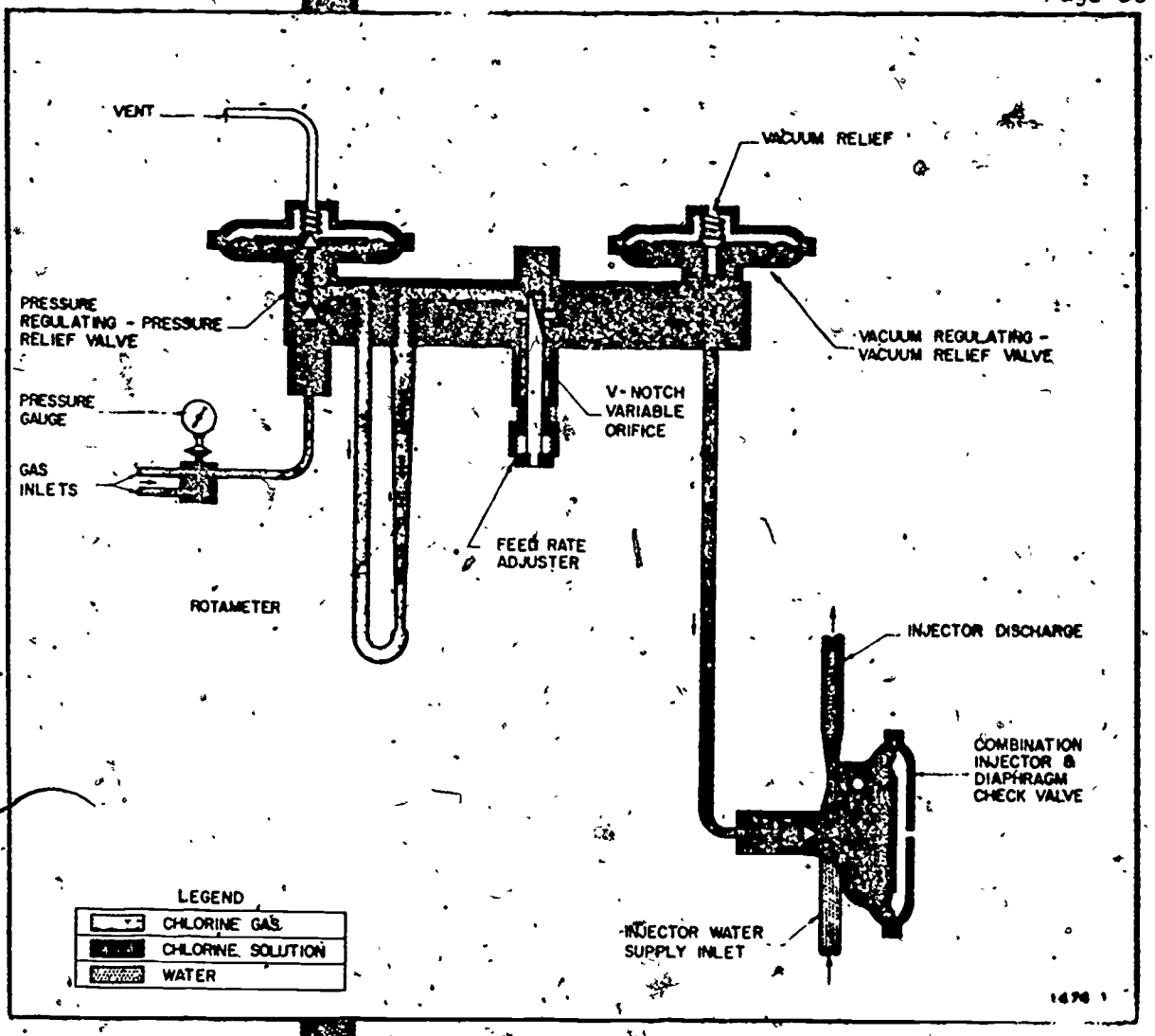
Read handouts
Participate in discussion

Module No:	Topic:

Instructor Notes:	Instructor Outline:

XIII. Methods of Chlorine Application

1. Gas
   - A. Pressure
   - B. Vacuum
2. Dry compound
   - A. Create a liquid mix and apply to the water.
   - B. Measure total needs
3. Solution - Sodium Hypochlorite
   - A. Supplied
   - B. On site generation of NaOCl



operation is obtained by interrupting the injector water supply, thus the operating vacuum. This is done by adding an optional solenoid valve or by any other convenient means of interrupting the injector water supply. Injector water is the only supply required by the V-75 Chlorinator. There is no make-up water, no drain. Injector materials resist corrosion and erosion.

SHORT DESCRIPTION

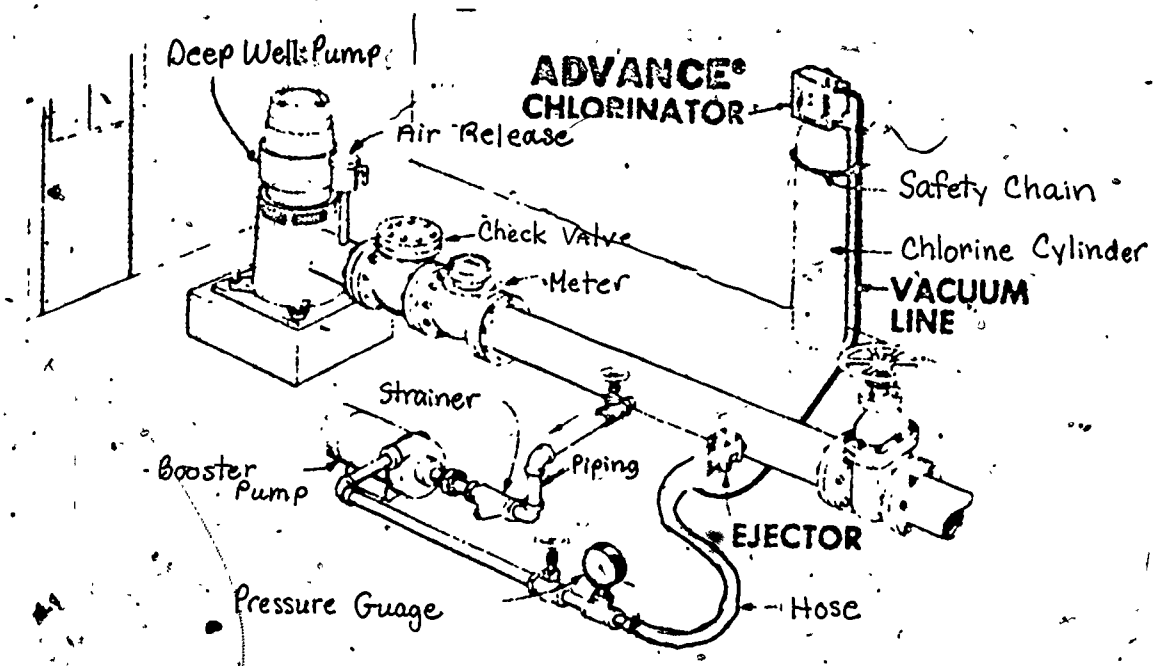
The Wallace & Tiernan Series V-75 Chlorinator is a solution-feed, vacuum-operated, wall-mounted type. A series of 13 rotameters provides capacities of 3, 10, 20, 30, 50, 75, 100, 150, 200, 250, 300, 400, or 500 lb of chlorine per 24 hours. Feed range is 20 to 1 for any one rotameter. The V-notch control method will maintain the set feed rate within 4%.

Operating components are mounted on a reinforced plastic panel with corrosion-resistant, vinyl enamel finish. A spring-loaded pressure regulating-pressure relief valve maintains the proper operating vacuum ahead of the V-notch orifice. It opens only under normal operating vacuum and vents to atmosphere if excessive gas pressure develops. Another spring-loaded valve maintains a constant vacuum downstream of the orifice. It also admits air if excess vacuum develops. This air does not pass through the rotameter. The valves are separate valves. They have sealed diaphragm units with Acme-thread sockets for removal and replacement without tools.

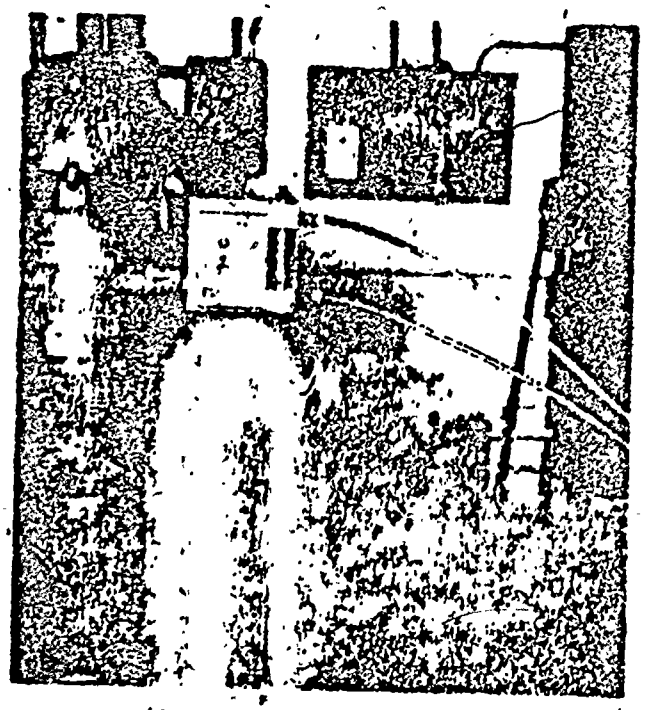
The rotameter has a 10-inch, linear scale. Its graduations and float are in contrasting colors for easy reading. The metering device is a V-notch Variable Orifice. It consists of a plastic plug with a V-shaped groove which moves in a fitted plastic ring. The aspirator-type injector prevents backflow of water into the chlorinator.

Operation requires no auxiliary water and no drain. A chlorine pressure [illegible] at the gas inlet is [illegible]. And

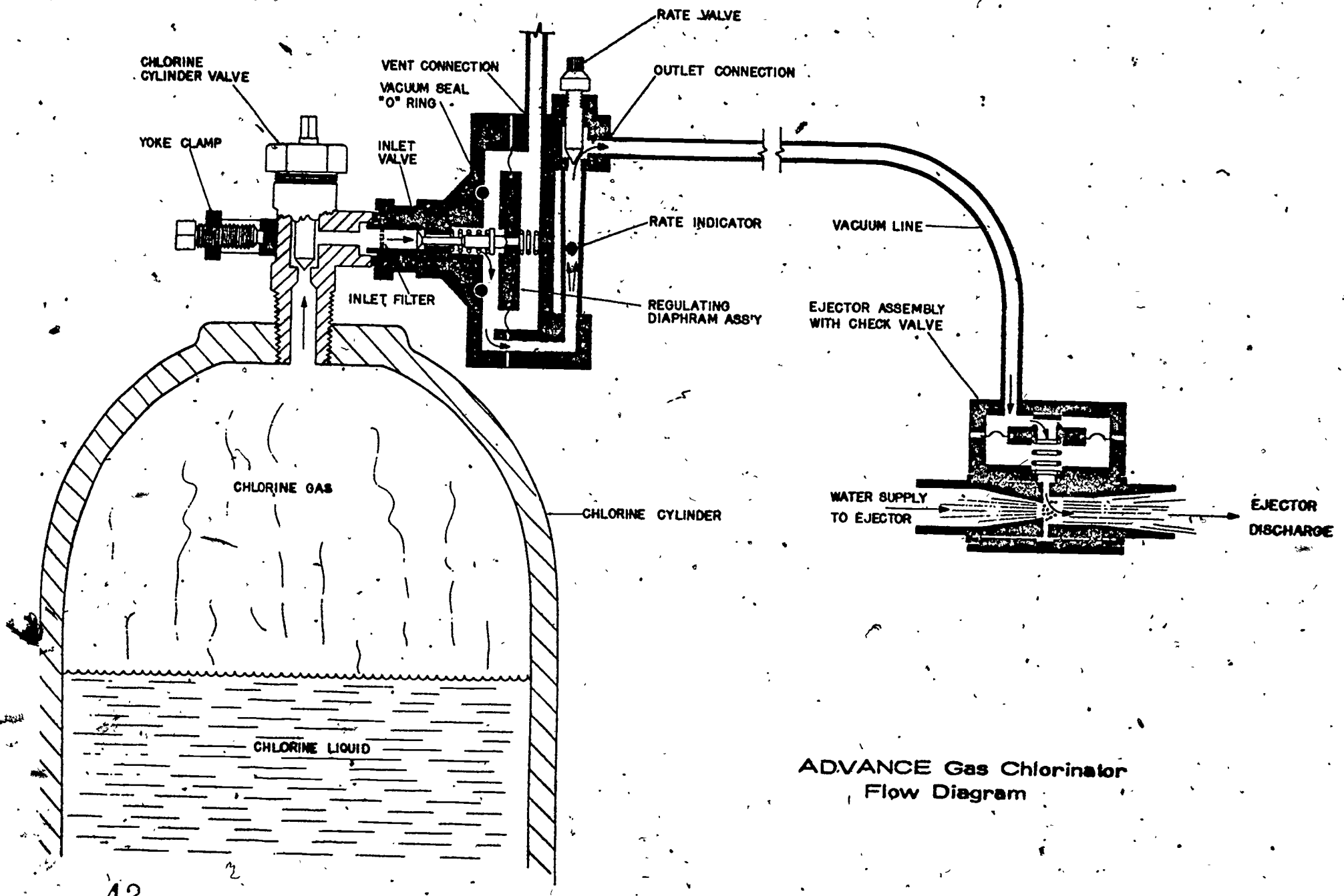
Handout 12



The illustration above shows a typical deep well pumping system installation using a centrifugal booster pump and a cylinder mounted ADVANCE gas chlorinator. Some wells may differ slightly from that shown. In general all such installations will have a main check valve to prevent water back flow at shut down. The problem is, to inject a metered amount of chlorine into a pressure main which may have a water pressure from 30 psi to 120 psi, or higher. The chlorinator and chlorine cylinder are shown in the same area as the well pump. If a separate building or area has been provided for the chlorinator, installation is the same, except that a longer length of vacuum tubing is necessary. The vent connection on the lower part of the chlorinator is connected to the outside with the same type of tubing.



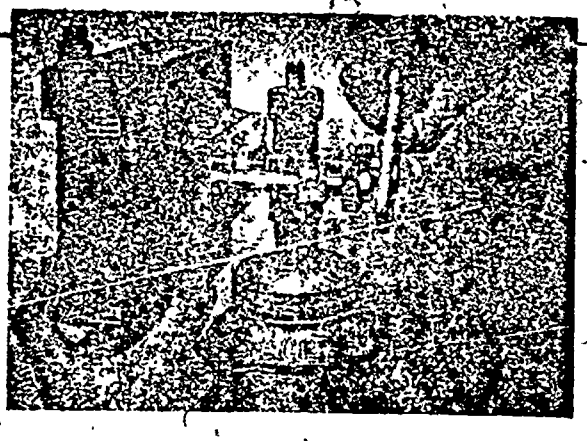
[illegible] at deep well installation



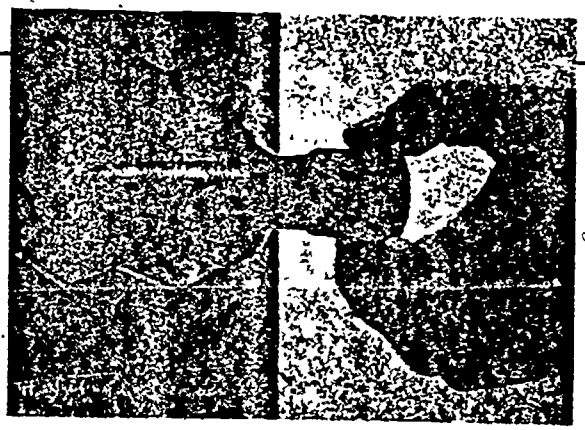
ADVANCE Gas Chlorinator
Flow Diagram

CHLORINATOR INSTALLATION
QUICK - EASY - SAFE

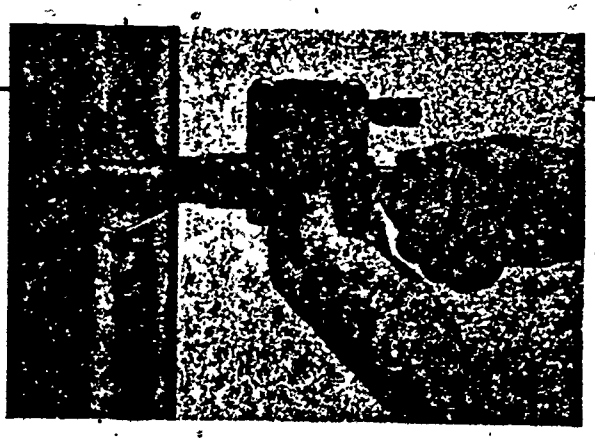
CAPITAL CONTROLS COMPANY, ADVANCE LANE, COLMAR, PA. 18915 • Phone (215) 822-2901



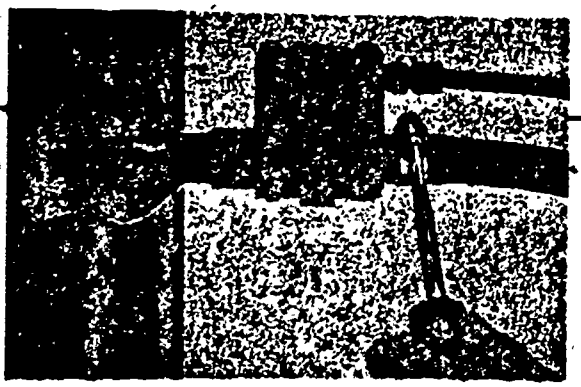
1. ATTACH CHLORINATOR TO CHLORINE CYLINDER VALVE.
Place chlorinator over cylinder valve — and simply clamp tight against gasket.



2. INSTALL CHLORINE SOLUTION DIFFUSER IN PIPE.
Screw diffuser hand tight into pipeline, using non-hardening pipe dope.



3. CONNECT EJECTOR TO DIFFUSER. Place water inlet fitting (nozzle) through ejector block, with gasket on each side. Screw water inlet into diffuser, hand tight.



4. CLAMP ON WATER SUPPLY HOSE AND CONNECT VACUUM TUBING TO COMPLETE INSTALLATION.

Module No:	Module Title: Chlorine
	Submodule Title: Chlorine Safety - Gas
Approx. Time: 1 hour	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. Identify the problems of using gas chlorine and the hazards the gas will have on the human system.
2. Identify the methods of reducing chlorine hazards.

Instructional Aids:

Handout 11

Instructional Approach:

Lecture
Discussion

References:

1. WPCF MOP #4 Chlorination of Wastewater
2. Operation of Wastewater Treatment Plants, Sacramento

Class Assignments:

Participate in discussion
Review handout

Module No:	Topic: Chlorination

Instructor Notes:	Instructor Outline:
	XIV. Chlorine Storage
	1. Dry room
	2. Indoors/outdoors
	3. If indoor - ventilate and make reasonably fireproof.
	4. Outdoor - avoid direct sunlight
Handout 15	XV. Chlorine Safety - Gas
	1. Do not use water to stop a Cl_2 leak. Water makes the leak bigger.
	2. Caution - Cl combines freely with moisture of any kind.
	3. Caustic soda will absorb Cl_2 at the rate of 1 lb. of Cl to 1.25 lb. of caustic soda.
4. Show kit if available	4. Kits to repair leaks
	"A" Kits - small cylinders
	"B" Kits - ton cylinder
	Both contain all tools to repair the cylinder.

WARNING

1 Irritant To Respiratory Tract

2 Deadly To Animals at 0.1% Concentrati

3 Maximum Safe 60 minute Exposure 0.0004% Air

4 Maximum 8 hr. : 0.0001% Air

5 Corrosive

6 Found At Bottom of Room

Module No:	Module Title: Chlorination
	Submodule Title: Maintenance of System
Approx. Time: 1 hour	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. Perform the necessary maintenance to pressure/vacuum systems.

Instructional Aids:

Handout 2

Instructional Approach:

Lecture
Discussion

References:

1. WPCF MOP #4
2. Manufacturer's Guide

Class Assignments:

Read handouts
Participate in discussions

Module No:	Topic:

Instructor Notes:	Instructor Outline:
XVI. Scale Weight of cylinder taken to measure Cl_2 used and when tank is empty. Water for mixing Cl_2 prior to point of application. Rotameter a glass tube where the opening is made wider at the top and narrow on the bottom - to measure Cl flow from the tank or cylinder.	XVI. Application Systems 1. Pressure systems Equipment Scale Water supply Rotameter Injector Shut Down 1. Turn off water to ejector 2. Shut valve to cylinder 3. Open ejector to reduce pressure in Cl line. Close when pressure decreases to zero. XVII. Maintenance 1. Pressure A. Check for leaks with ammonia solution or rag or spray bottle. B. Clean rotameter and float. C. Valves in direct contact with Cl_2 should be cleaned yearly. D. Use new gaskets whenever a line is disturbed regardless of reason. 2. Vacuum A. Check for Cl_2 leaks. B. Clean rotameter and ball C. Clean ejector nozzle of impurities every 6 months.

Module No:	Module Title: Chlorination
	Submodule Title: Changing Tanks
Approx. Time: 1 hour	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. Identify the steps in changing chlorine tanks.

Instructional Aids:

- Demonstrate
- Use handout #4

Instructional Approach:

Lecture
Discussion

References:

1. Manufacturer's Guide

Class Assignments:

Participate in class discussion

Module No:	Topic: Changing Tanks
Instructor Notes:	Instructor Outline:

Handout 4

XVIII. Chlorine Tanks - Changing

1. Turn on fan in room
2. Wait 60 sec. to vent room
3. Shut off cylinder
4. Break cylinder bolts
5. Replace with new tank
6. Use new washers. Do not reuse old washers.
7. Thread assembly to valve carefully.
8. Open valve
9. Check for leaks. If leaks shut off immediately. If no leaks 60 to 10.
10. Open all valves for chlorine and water.
11. Adjust chlorine flow rate through rotameter.

Module No:	Topic:

Instructor Notes:	Instructor Outline:
Demonstrate by showing the flammability of dry chlorine	XIX. Calcium Hypochlorite 1. Dry form - used infrequently in the disinfection of water/wastewater. Primarily as a standby for emergency; pipe disinfection spot chlorination. 2. Equipment needed a. Solution mixing basin b. Metering pump for feeding the solution to the water. 3. Safety - this form of chlorine is highly explosive. DO NOT SMOKE or use flame around this powder. 4. Mixing - 1 lb. of calcium hypochlorite to 10 gal. of water yields 89 ppm of chlorine in solution. CAUTION: During mixing the action creates an escape of free chlorine gas. This gas supports combustion. XX. Sodium Hypochlorite 1. Liquid - prepared 2. On site generation 1. Dilute solutions of chlorine (NaOCl) strong corrosive.

Module No:	Topic:
Instructor Notes:	Instructor Outline:

A. Solution will decompose quickly in light or heat atmosphere.

B. Fed to the water/wastewater by means of a positive displacement pump.

2. Generation on site is becoming a popular trend as the quantity and quality has many advantages over shipping of the solution.

A. Caution is to be used as hydrogen gas is a by-product and can be dangerous if not handled properly.

B. Slurries are prepared in advance and added to the water/wastewater by means of proportional pumps.

CAUTION: The slurry will encrust in the system, maintenance requirements - makes automation impractical.

Module No:	Module Title: Chlorination
	Submodule Title: Interpretation of Test Results
Approx. Time: 45 minutes	Topic:

Objectives:

Upon completion of this module the participant will be able to:

1. Interpret results of the chlorine tests for:
   A. Residual
   B. Free

Instructional Aids:

None

Instructional Approach:

Lecture
Discussion

References:

1. WPCF MOP #4
2. AWWA Water Chlorination Principles and Practices

Class Assignments:

Participate in discussion

Module No:	Topic:
Instructor Notes:	Instructor Outline:

XXI. Interpretation of test results

1. Residual chlorine
2. Free chlorine

1. Residual chlorine is the amount of chlorine that is required to meet the demand of disinfection.

   A. The State of Iowa has established a residual by the plant effluent based on receiving water standards.

   B. If your results are less than the stated value, adjustment of the chlorine application is needed. The opposite is also true as too much chlorine is harmful to the receiving waters.

2. Free chlorine is the end product after all the chlorine has been used to combine with organics and chemicals. This end product is a hypochlorous acid, a hypochlorite ion.

   Free chlorine will react quickly with any property to eliminate/reduce control taste and odor. Any uncombined chlorine could be the cause of the chlorine taste in drinking waters.

   Once the demand of combined residual is met, the free chlorine allows the continuation of disinfection within the system by concentrating on the problems of disinfection taste and odor control.

Module No:	Module Title:
	Submodule Title:
Approx. Time: 1½ hours	EVALUATION

Objectives:

After completion of this module the participant will be able to:

1. Label key parts on a schematic of
   a. Pressure systems
   b. Vacuum systems
2. List first aid steps for a victim exposed to large doses of chlorine.
3. List the reactions of the three forms of chlorine when mixed with water.
4. Define:
   a. Free available chlorine
   b. Chlorine residual
5. List and identify points where chlorine could be applied.
6. Upon compeltion of this module the participant should be able to correctly answer 80% of the evaluation questions.

EValuation Questions

1. Define purpose of chlorination.
2. Label vacuum diagram provided by instructor.

Rotameter	Pressure
Rate valve	Yoke clamp
Chlorine cylinder valve	Water supply

3. Below are the first aid steps covered in the module. Fill in the blank statements.

   A. Get outside

   B. Keep victim warm ($70^{o}F$).

   C. _____

   D. Remove victims wet clothes

   E. _____

   F. Reduce or stop coughing, if possible

   G. Do not administer drugs or liquids

4. A chlorine leak is detected by _____

   _____

5. Why would chlorine be applied to:

   a. Odorous manhole

   b. Pump suction wells

   c. Forced mains

   a. _____

   b. _____

   c. _____

6. Reaction of chlorine in water sets off different results when different forms are used. List results below.

   Gaseous Cl_2 Dry Cl_2 Liquid Cl_2

7. List percentage of chlorine forms memtioned in questions 6 in same order as listed in question 6.

8. Define:

   a. Free available chlorine

   b. Chlorine residual

   a.

   b.

9. Your plant has a residual chlorine of 0.3 mg/l. What must you do?

   Why?

10. Your plant has a residual chlorine of 2.6 mg/l. What must you do?

    Why?

Module No:	EVALUATION

Instructor Notes:

Answers

1. The purpose of chlorination is to reduce pathogenic bac bacteria, preventing the spread of disease.
2. Refer to handout.
3. C. Call a doctor
   E. If not breathing use a respirator
4. Ammonia detection
5. a. Prevent odors
   b. Slime growth/odors
   c. Slime growth
6. Gas

   $Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$

   Dry

   $Ca(OCl)_2 + H_2O \rightarrow Ca^{2+} + 2OCl^-$

   Liquid

   $NaOCl \rightarrow H_2O \rightarrow Na^+ + OCl$
7. 99.9% Gas
   70 % Dry
   5-30% Liquid

Instructor Outline:

Upon completion of the module the instructor will passout the test to evaluate student performance.

1. Where a student is asked to "define" an answer the answer may be approximate to the given correct answer.
2. For answer use handout 12 and 13 as master and question sheet.

Module No:	EVALUATION
Instructor Notes:	Instructor Outline:

8. Free available chlorine - the amount of chlorine available in a liquid that is not combined with any organic compound.

   Chlorine residual - the amount of chlorine available as a dissolved gas, acid, or ion that will combine with any organic compound.

9. Raise the level to that allowed by permit.

   To insure a reasonable level of disinfection takes place.

10. Lower level to permit value to reduce possible harmful effects of stream Biota.